DEVELOPMENT CONTROLLER FOR 2 AXIS MECHANISM MACHINE

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ABSTRACT

In engineering application most of part is machining to make it realize, an example plastic product. Moulds are machine by using Milling machine, turning machine and EDM machine. This entire machine is using a same concept that was 2 axis mechanisms to move the table. This thesis is focus on controlling stepper motor in axis during machining process in term of positioning motion control. All of the task would be control by using Visual Basic Programming. This project is limited to low cost automation and low servo speed. The device or 3 axis machine has been develop before this, this machine are using stepper motor to move the table, this is because step motor provides efficiently and precise movement that required during application in machining. During this development of controller there are no manufacturer product catalogues, outlining characteristic and rating of actuators that can helps engineer. However, because of lack information, engineers resolve to choose based an experience. From this project, the criteria in the selection aid focus in type of nature of control requirement by the application such as position control, speed control and torque control requirement.

ABSTRAK

Dalam aplikasi kejuruteraan sebahagian besar daripada bahagian mesin akan dimesin untuk merealisasikannya , produk plastik misalnya. Acuan akan dimesin dengan menggunakan mesin raut, mesin larik dan mesin EDM. Keseluruhan mesin ini menggunakan konsep yang sama iaitu mekanisme 3 paksi untuk menggerakkan meja kerja. Tesis ini memfokuskan kepada pengendalian motor semasa proses memesin ,didalam maksud posisi kawalan pergerakkan. Semua kawalan ini akan menggunakan Visual Basic program. Projek ini terbatas untuk automasi kos murah dan kecepatan servo rendah. Mesin 3 paksi telah dibangunkan sebelum ini, mesin ini menggunakan stepper motor untuk menggerakkan meja kerja, ini kerana motor ini memberikan gerakan yang cekap dan tepat yang diperlukan semasa proses memesin dilakukan . Semasa pembangunan kawalan untuk motor stepper ini, tiada katalog disediakan oleh pembuat produk yang dapat menghuraikan ciri-ciri dan penarafan penggerak yang dapat membantu jurutera. Namun, kerana kekurangan maklumat, jurutera memutuskan untuk memilih berdasarkan pengalaman. Daripada projek ini, ciri-ciri pemilihan tumpuan bantuan jenis sifat keperluan kawalan oleh permohonan seperti kawalan kedudukan dan kawalan kelajuan.

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LIST OF SYMBOLS

F	Force
Ω	Ohm
Lw	Inductor
Rw	Resistor
V	Volt
A	Ampere
θ	Rotation Angle
θs	Step Angle
A	Pulse Number
N	Speed of The Motor
f	Pulse speed in Hz

LIST OF ABBREVIATIONS

PTP	Point to Point
DC	Direct Current
AC	Accumulative Current
PLC	Programmable Logic Controller
CNC	Computer Numerical Control
RPM	Rotation per Minute
CW	Clock Wise
PCB	Printed Circuit Board
EDM	Electrical Discharge Machine

CHAPTER 1

INTRODUCTION

1.1 Project Background.

Nowadays lots of machine has been produce to use for making parts such as in automotive industries, food industries, plastic industries and etc [4]. Behind these industries all machine has been produce by using turning machine and milling machine. These two machines are a basic machine that use in all machining processes to produce parts machines and make the engineering process easier and efficiencies. [2]

Material removing process can be divided into mainly two groups which are conventional and non conventional machine. Conventional machining processes mostly remove material in the form of chips by applying forces on the work material using a wedge shaped cutting tool that is harder than the work material under machining condition, example milling, turning, grinding etc. Non conventional machining usually known as advance machining. This type of machining the tool does not to be harder than the work piece material. For example, in EDM, copper is used as the tool material to machine hardened steels, non conventional machining also may not represent physical tool example in laser jet machining, machining is carried out by laser beam. This non-conventional machine mostly integrated with Computer Numerical Control (CNC) [7].

The advantages using CNC in machining process is its easier to control, precise machining and complex parts can be machine using three axis platform. Three axis machines is a basic machine in manufacturing in producing small part to the large size of any part in machine, it starts to increase the automation Industries in manufacturing field. In addition, three axis machines are more flexibility in time to produce different components.

In this project, control system for two axis mechanism machine will be developed by using Visual Basic as software, this control system will be used to control the movement of this mechanism, control system is a device or set of the device to control, manage, command, direct or regulated behavior of other device or system. [3]

1.2 Project objectives

1. To design a control system for two axis mechanism machine.
2. To test and analyze the parameters and characteristics of tracking control of feed drive in machine.

1.3 Scope of project

1. Design a control system for two axis mechanism machine using Visual Basic.
2. Testing and programming for machining setup.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to control system

Control system is a one of discipline in engineering field. “Control system” is a device or set of the device to control, manage, command, direct or regulated behavior of other device or system. A control system consist of subsystem and process (or plants) assembled for the purpose of obtaining a desired output with desired performance, given a specified input. [3]

Modern manufacturing such as machine tool is supported by servo system that provides two fundamental functions that was regulation and maneuvering. The regulation function is required to maintain the controlled object at a desired position in the presences of external distribution in maneuvering control, the motion can be classified in two cases point to point (PTP) and countering (or tracking) when controlled object is moved along a prescribed trajectory. In PTP control the final positioning accuracy and the transition time are important while the transient path is of secondary importance. Positioning a drill bit in machining center is a typical example of PTP controller. In tracking control, the controlled object must be moved along a desired trajectory and the error during transient must also be minimized. Example of tracking control is can be found in milling operation such as machining in circular work-piece. [8]

In this system, a DC motor is used as the power set of the feeding mechanism. Compared with AC motor control, DC motor's drive circuit is more simple and reliable. Moreover, the speed adjusting accuracy and dynamic response characteristics of the DC motor are more ideal with a greater speed range and higher speed adjusting accuracy.

2.2 Components in Two Axis Machine

Basically in two axis machine there don't have more than 10 components in the machine to make a movement. Axis are a direction of a motion control by the servo motor. The number of axis a machine has determine s it's machining capabilities, the number of axis in a certain movement machine is depends on the application example in automotive industries to produce cylinder block for car engine there need more angle for machine this part so maybe they need 5 axis machine to meet the requirement for machining process.

In order to understanding a two axis mechanism machine, there is a need to determine which the components have to utilize so that it can perform smoothly and efficiency. The components in 2 axis machine are:-

i). Linear slides
ii). Ball bearing slides
iii). Dove tail slides
iv). Machine slides
v). Roller slides
vi). Roller tables
vii). XY table

2.2.1 Linear Motion System

Linear motion system is a system that provides movement to the three axis machine, usually linear motion system using for straight movement of slider to move one point to another point by a system such as slider. A modern motion

system typically consist of a motion controller, a motor drive or amplifier, an electrical motor, and feed back sensor. The system might also contain other components such as one or more belt, ballscrew or lead screw that function to drive linear guide or axis stages. [1]

A motion controller today can be stand alone programmable controller, a personal computer containing a motion control card, or a programmable logic controller (PLC). All of the component of a motion control system must work together so that their can performed their assigned functions. All of their selection must be based on both engineering and economic consideration. Figure 2.1 below illustrate linear motion control that have 3 axis machine.

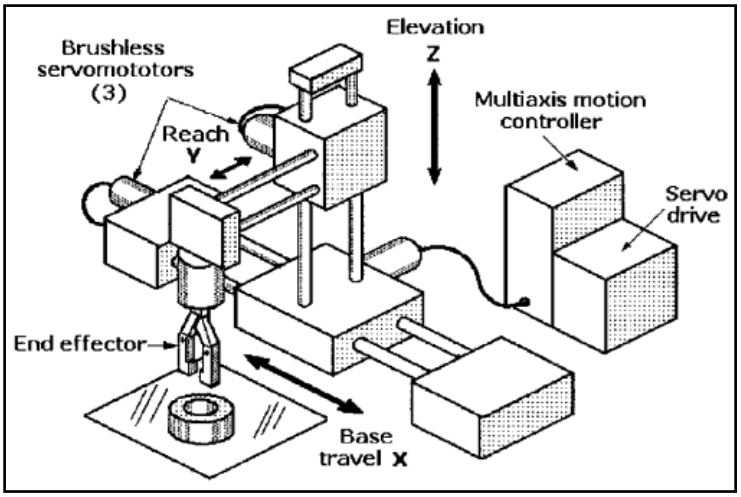

Figure 2.1: Linear Motion in 3 axis machine [1]

With additional mechanical electro mechanical components on each axis, rotation on three axis can provide up to six degree of freedom show in Figure 2.2 below.

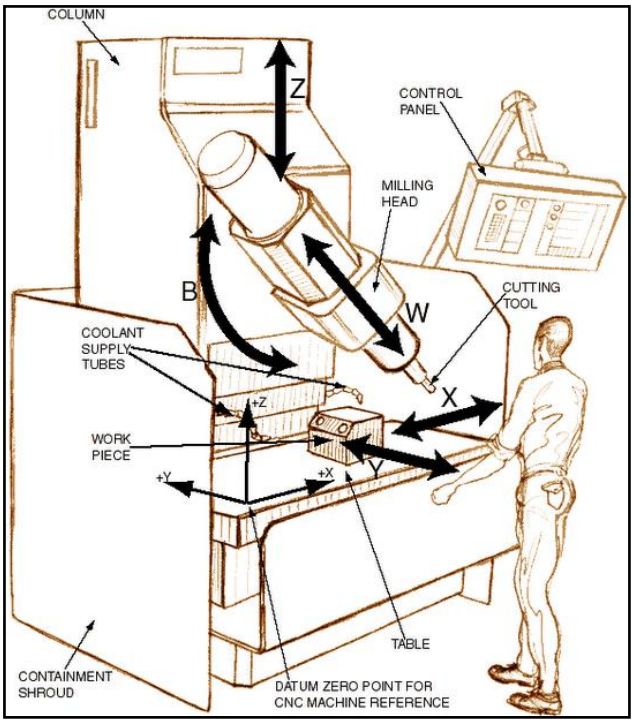

Figure 2.2: 6 axis milling machine

Each of axis that provide in three axis machine have their own function, this axis develop base on the application that need in machining process, table 2.1 show machine tool axis definition.

Table 2.1:ISO Machine tool axis definition

<table>
<tr><td>AXIS</td><td colspan="3">MACHINE TOOL WITH SPINDLE</td><td>MACHINE TOOL WITH NO SPINDLE</td></tr>
<tr><td>Z</td><td colspan="3">axis of spindle,
(+Z) as tool goes away from the work piece</td><td>perpendicular to work holding surface, (+Z) as tool goes away from the workpiece</td></tr>
<tr><td rowspan="3">X</td><td>MACHINE TOOL WITH ROTATING WORKPIECE</td><td colspan="2">MACHINE TOOL WITH ROTATING TOOL</td><td></td></tr>
<tr><td></td><td>HORIZONTAL AXIS</td><td>VERTICAL AXIS</td><td></td></tr>
<tr><td>radial and parallel to cross slide, (+X) when tool goes away from the axis of spindle</td><td>horizontal and parallel to work holding surface, (+X) to the right when viewed from spindle towards work piece</td><td>horizontal and parallel to the work holding surface, (+X) to the right when viewed from spindle towards column</td><td>parallel to and positive in the principal direction of cutting (primary motion)</td></tr>
<tr><td>Y</td><td colspan="4">apply right hand rules</td></tr>
</table>

2.2.2 Linear slides

linear slides are designed for robust applications that demand high thrust along with high-precision accuracy and stiffness. This configuration of drive and guide is just one of several pre-assembled, ready-to-install linear slides available to mechanical motion engineers. All provide low friction and smooth, accurate motion for a wide range of moment or normal loading configurations.

Application of the linear slides is to move mounted mechanisms across a given axis either in one direction or combine of three or more directions. Complete linear slides normally consist of at least a base, a saddle, adjusting screws and a straight rib. Linear slides are resistant to contamination, extremely durable in shock load conditions and run smoothly on lightweight frames .Figure 2.3 below shows the example of linear slide that usually have in market.

Figure 2.3 : Linear slide [12]

There are some advantages of using linear slide. Some of them are: -

i. Products that having a wide range of weights, from lightweight miniatures to payloads of several hundred pounds can be move easily.
ii. Products can be move in distances that range from as little as 2.5 millimetres to 1.5 meters.
iii. Rapidly position their loads.
iv. They position their loads so precisely, that the final positioning can be measured in microns (millionths of a meter).

2.2.3 Ball bearing slide

Also known as "ball slides", ball bearing slides are the most common type of linear slide. Ball bearing slides offer smooth precision motion along a single-axis linear design, aided by ball bearings housed in the linear base, with self-lubrication properties that increase reliability. Ball bearing slide applications include delicate instrumentation, robotic assembly, cabinetry, high-end appliances and clean room environments, which primarily serve the manufacturing industry but also the furniture, electronics and construction industries. For example, a widely used ball bearing slide in the furniture industry is a ball bearing drawer slide.

Commonly constructed from materials such as aluminium, hardened cold rolled steel and galvanized steel, ball bearing slides consist of two linear rows of ball bearings contained by four rods and located on differing sides of the base, which support the carriage for smooth linear movement along the ball bearings. This low-friction linear movement can be powered by either a drive mechanism, inertia or by hand. Ball bearing slides tend to have a lower load capacity for their size compared to other linear slides because the balls are less resistant to wear and abrasions. In addition, ball bearing slides are limited by the need to fit into housing or drive systems. Ball bearing slides mostly use for delicate instrumentation, the structure of ball screw is shown in figure 2.4 next page.

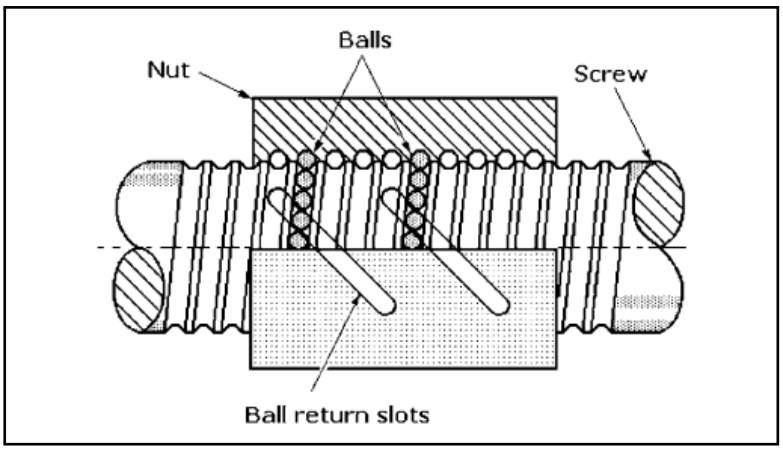

Figure 2.4 :Ball Screw drive: ballscrew use recirculating balls to reduce friction and gain higher efficiency than conventional lead screws. [1]

2.2.4 Dovetail Slide

Dovetail slides or dovetail was a slide are typically made from cast iron, but can also be constructed from hard-coat aluminium, acetyl or stainless steel. Like any bearing, a dovetail slide is composed of a stationary linear base and a moving carriage. A Dovetail carriage has a v-shaped, or dovetail-shaped protruding channel which locks into the linear base's correspondingly shaped groove. Once the dovetail carriage is fitted into its base's channel, the carriage is locked into the channel's linear axis and allows free linear movement. When a platform is attached to the carriage of a dovetail slide, a dovetail table is created, offering extended load carrying capabilities. Figure 2.5 below illustrate traditional dovetail.

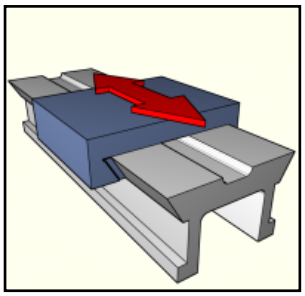

Figure 2.5: Traditional dovetail slide

Since dovetail slides have such a large surface contact area, a greater force is required to move the saddle than other linear slides, which results in slower acceleration rates. Additionally, dovetail slides have difficulties with high-friction but are advantageous when it comes to load capacity, affordability and durability. Capable of long travel, dovetail slides are more resistant to shock than other bearings, and they are mostly immune to chemical, dust and dirt contamination.

Dovetail slides can be motorized, mechanical or electromechanical. Electric dovetail slides are driven by a number of different devices, such as ball screws, belts and cables, which are powered by functional motors such as stepper motors, linear motors and handwheels. Dovetail slides are direct contact systems, making them fitting for heavy load applications including CNC machines, shuttle devices, special machines and work holding devices. Mainly used in the manufacturing and laboratory science industries, dovetail slides are not ideal for high-precision applications.

2.2.5 Machine Slide

Machine slide mostly use in CNC machine for linear movement, to move the machine slide several part include of AC/DC motor, ball bearing slide, and roller slide need for that function. By using machine slide higher rigidity of the machine can be retained, which create accurate linear motion for the machine for all application include roughing and drilling in CNC milling machine. For machine slides it’s have adjustable ribs in order to make up for any irregular movement that maybe develop during application.

Machine slide can be single, double or multi axis, in this project three axis will be use. Some of standard machine slide include dovetail slide, hardened way slide, linear guide slide and more. Figure 2.6 show in the next page is machine slide for CNC milling.

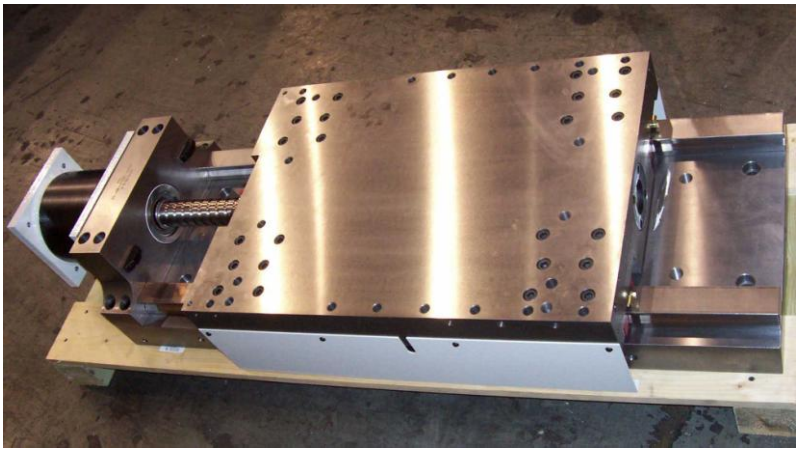

Figure 2.6: Machine slide for CNC milling [13]

2.2.6 Roller slide

Roller slide that also known as crossed roller slides, this equipment are non-motorized linear slides that provide low-friction linear movement for equipment powered by inertia or by hand. Roller slides are based on linear roller bearings, which are frequently criss-crossed to provide heavier load capabilities and better movement control. The example of roller slide is shown in figure 2.7 below.

Figure 2.7: Roller slide made from stainless steel [13]

Its utilize rollers that crisscross each other at a 90° angle and move between the four semi-flat and parallel rods that surround the rollers. The rollers are between "V" grooved bearing races, one being on the top carriage and the other on the base. The design of' crossed roller slides allows them to carry up to

twice the load of ball bearing slides and to absorb larger impacts or stackable to create multi-axis linear motion.

Serving industries such as manufacturing, photonics, medical and telecommunications, roller slides are versatile and can be adjusted to meet numerous applications which typically include clean rooms, vacuum environments, material handling and automation machinery.

2.2.7 Roller Tables

The other part in three axis mechanism is roller table. It functions to front sliding surface and rear sliding surface that longitudinally aligned. For secure to rear supporting group, lifting levers are pivoted on a bearing bar. The levers have feeler pins engaged in sliding manners along guiding grooves, which are shaped so that when the front and rear supporting groups are moved away from each other.

2.2.8 XY table

There are various type of XY table being used in machine technology. The apparatus is applied in positioning element mechanism of lathe, milling and other machine. The most was applied in positioning element mechanism of lathe, milling and other machine. The most was applied in Computer Numerical Controller (CNC) machining centre. The XY table is use for moves to work of marking, cutting, drilling and others. The name of XY table is because of the prime activity X and Y axis. Then, there is also Z axis which is for the vertical axis. Figure 2.8 show the example of XY table machine.

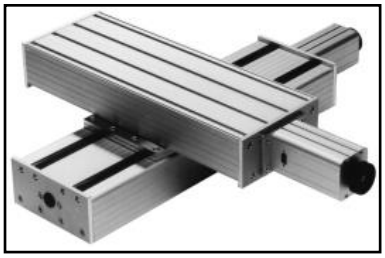

Figure 2.8: XY table machine [14]